

A NOTE ON THE RELATIONSHIP BETWEEN CLOUD AND SUNSHINE.

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On a cloudless day a perfect sunshine recorder would show 100 per cent. of the optimum of sunshine. The ordinary sunshine recorders in use show less, because the record ceases when the sun is very low down, rising or setting.

The recorder in use at Kenilworth (Kimberley) is of the Jordan hemi-cylinder photographic type. The paper used with it is not sensitive to the rays from a low sun; and besides, it has not a good horizon, so that at the best it does not record more than 96 per cent. or so of what a perfect instrument would do. When the sun is high enough the instrument gives an excellent record, indicating with a considerable approach to exactitude, and with very little overlapping, the duration of the transit of the lower clouds over the sun. The higher, and thinner, clouds do not interrupt the sunshine very much.

Now any trace of sunlight on the sensitised paper is counted as sunshine; therefore if the sky were covered with thin cirrus all day, transmitting some sunshine, it would be possible to get this condition.

Sunshine	+	Cloud	=	Total
96	+	100	=	196 per cent.

Again suppose 40 per cent. of the sky to the southward to be covered with either cumulus or stratus all day, but no cloud to cross over the sun, then we should have—

Sunshine	+	Cloud	=	Total
96	+	40	=	136 per cent.

These are extreme cases of course, but we may nevertheless expect in general the monthly and yearly sums of sunshine and cloud to exceed 96 per cent.; and this proves to be the case. The following table shows the mean percentages of sunshine and cloud at Kenilworth for each month of the year, the cloudiness being deduced from daylight observations made at 800, 1100, 1400 and 1700 each day. The period from which the means are obtained is the twenty years 1900 to 1919.* Annual means for Hong-Kong, Córdoba and Mauritius are added for purposes of comparison. The Hong-Kong cloudiness is that of the mean of hourly observations, day and night, that of Córdoba is deduced from the daylight hours only, that of Mauritius from observations at 600, 900, 1300, and 1500.

* January, 1917, is omitted.

TABLE I.—*Monthly Means of Sunshine and Cloudiness at Kimberley.*

	Sunshine (%).	+	Cloud (%).	=	Total (%).
January	75·3	.	41·1	.	116·4
February	72·2	.	45·8	.	118·0
March	73·7	.	41·8	.	115·5
April	79·2	.	32·5	.	111·7
May	81·7	.	26·7	.	108·4
June	81·8	.	23·7	.	105·5
July	82·7	.	20·3	.	103·0
August	83·8	.	20·5	.	104·3
September	79·4	.	32·8	.	112·2
October	77·4	.	38·0	.	115·4
November	78·0	.	37·2	.	115·2
December	76·7	.	38·8	.	115·5
Year	78·5	.	33·3	.	111·8
Hong-Kong (year)	43·8	.	66·6	.	110·4
Córdoba „	63·0	.	48·0	.	111·0
Mauritius „	64·5	.	57·0	.	121·5

The October numbers in the Kimberley table are curious—a drop in the sunshine and a rise in the cloudiness as compared with September and November. This effect seems to be common to the central Tableland of South Africa. Leaving out of account the October irregularity there is a maximum of sunshine early in August and a minimum late in February, a maximum of cloudiness towards the middle of February and a minimum about the end of July, sunshine and cloudiness together being greatest about the first week in February, and least about the last week of July. Evidently the cloudiness decreases faster from its maximum than the sunshine increases from its minimum.

The table indicates roughly that the lower the percentage of sunshine and the higher the percentage of cloud, the higher the percentage of the sum of the two. This effect is analysed at greater length in Tables II and III at the end. Table II shows, for each grade of cloudiness from less than 15 per cent. to more than 51 per cent., the variations month by month in the percentages of sunshine plus cloud. In each month there is a strong trend to greater numbers as the cloudiness increases, while the annual means are in substantial agreement with the monthly means of Table I. Thus a cloudiness of 45·8 per cent. in February goes with 118 per cent. of sunshine plus cloud, as a cloudiness of 45 to 46 per cent. in Table II goes with 117 per cent. of sunshine plus cloud. Other corresponding numbers above :

Table I	23·7%	and	105·5%.
Table II	23 to 24%	and	105·1%.
Table I	37·2%	and	115·2%.
Table II	37 to 38%	and	115·9%.

TABLE II.—Percentages of Sunshine plus Cloud compared with Percentages of Cloud.

Cloud (%).	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.	
													Times.	Mean.
15 and less	—	—	—	—	3 100	1 100	6 97	6 100	2 100	—	—	—	18	99.1
16 to 20	—	—	—	1 100	3 106	4 104	4 105	3 104	—	—	1 109	—	16	104.6
21, 22	—	—	—	—	1 105	4 105	2 103	2 104	—	1 107	—	—	10	104.4
23, 24	—	—	—	3 109	—	3 105	1 106	2 100	1 103	—	—	—	10	105.1
25, 26	—	—	—	1 108	2 106	1 109	2 106	2 106	3 111	1 111	1 111	2 108	15	108.3
27, 28	—	—	—	2 110	2 112	2 104	—	1 111	2 111	—	2 110	—	14	109.6
29, 30	1 111	—	2 110	4 109	—	2 112	3 106	3 110	1 111	2 116	1 110	1 110	18	110.0
31, 32	—	1 110	—	—	—	3 106	1 109	—	1 115	—	—	—	9	110.0
33, 34	3 111	—	—	1 114	—	—	—	—	2 114	1 112	1 115	1 116	16	113.5
35, 36	1 112	3 114	2 111	5 114	1 112	—	—	1 111	—	4 114	4 115	2 114	14	113.7
37, 38	1 111	—	1 114	—	—	—	—	—	1 114	—	2 115	2 119	13	115.9
39, 40	2 116	—	3 117	2 112	1 113	—	1 108	—	2 117	3 116	1 115	3 118	21	115.0
41, 42	5 115	3 114	1 113	1 114	1 120	—	—	—	—	1 117	2 118	4 114	11	115.3
43, 44	—	—	1 113	2 114	1 117	—	—	—	—	2 115	—	1 118	8	116.0
45, 46	—	1 119	1 110	1 115	1 113	—	—	—	1 118	2 117	3 117	2 119	10	117.0
47, 48	1 118	1 118	—	—	—	—	—	—	2 116	1 119	—	2 120	13	119.0
49, 50	1 122	3 119	8 120	1 117	—	—	—	—	1 120	1 116	—	—	11	118.3
51 and more	4 118	4 118	5 119	—	—	—	—	—	—	1 122	2 126	—	12	121.7

TABLE III.—Percentages of Sunshine plus Cloud compared with Percentages of Sunshine.

Sunshine (%).	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.	
													Times.	Mean. Smoothed Mean.
66 and less	1 119	3 122	2 111	—	—	—	—	—	1 112	—	1 111	—	8	116.4
67	1 126	1 115	3 116	—	—	—	—	—	—	2 113	—	—	7	116.6
68	—	1 117	—	—	1 113	—	1 108	—	—	—	—	—	3	112.7
69	—	1 118	1 118	1 111	—	—	—	—	—	—	—	—	3	115.7
70	—	1 127	1 118	2 113	—	—	—	—	—	—	1 127	—	5	117.5
71	2 117	1 119	1 119	—	—	—	—	—	2 118	1 122	—	2 112	9	117.1
72	—	3 121	1 113	1 115	—	—	1 101	1 95	1 120	2 118	1 124	4 118	15	115.9
73	1 118	—	1 113	—	2 115	—	—	—	—	—	1 119	—	5	116.0
74	1 122	2 114	1 122	1 114	—	3 104	—	—	1 113	—	—	2 117	11	113.0
75	4 118	—	1 117	1 117	—	—	—	2 108	1 118	1 117	1 120	2 117	10	117.9
76	2 113	1 119	1 126	—	—	1 108	—	—	1 110	1 115	3 116	12	12	113.9
77	3 117	—	—	—	2 110	—	1 109	—	1 114	3 117	2 115	1 113	13	114.3
78	2 114	—	2 114	1 116	3 111	—	—	—	—	3 114	2 113	—	13	113.3
79	2 111	1 113	2 113	1 112	1 109	1 102	1 108	1 105	—	1 114	—	2 111	13	110.3
80	—	1 110	2 117	3 108	1 110	—	2 107	—	2 105	1 116	2 113	2 119	16	111.4
81	1 113	—	1 118	2 114	1 109	4 104	3 100	2 103	1 111	1 118	1 110	2 113	19	108.3
82	1 119	—	—	—	—	3 106	2 100	2 109	3 118	1 113	2 115	2 118	11	109.5
83	1 111	1 116	—	3 113	1 105	1 109	1 106	1 105	3 118	1 113	—	—	15	112.5
84	—	—	1 112	1 100	1 109	2 111	—	4 106	1 109	—	1 110	—	11	107.8
85	—	—	—	1 112	—	—	2 102	1 105	1 99	2 109	1 111	—	8	106.1
86	—	—	—	1 109	—	1 102	—	—	2 112	—	—	—	4	108.8
87	—	—	—	—	3 108	2 106	1 107	—	1 100	—	—	—	7	106.4
88	—	—	—	—	1 95	—	—	2 103	—	—	—	—	3	100.7
89	—	—	—	—	1 107	1 111	2 98	—	1 114	—	—	—	5	105.8
90	—	—	—	—	—	1 100	1 108	2 102	—	1 120	—	—	5	106.4
91 and more	—	—	—	1 114	2 102	—	2 98	2 100	—	—	1 109	—	8	103.1

Table III shows, for each grade of sunshine from less than 66 per cent. to greater than 91 per cent., the variations month by month in the percentages of sunshine plus cloud. In each month there is a tendency to smaller numbers as the sunshine increases; but the annual means (especially when they are smoothed in threes, as in the last column), although they establish a gradual fall, do not give the same rate of fall as Table I. Thus in Table III 70 per cent. of sunshine corresponds to 117·5 per cent. of sunshine plus cloud, while 89 per cent. of the one corresponds to 104·8 per cent. of the other—that is, a rising range of 19 per cent. of the one corresponds to a falling range of 12·7 per cent. of the other. As against this a rising range of about 11 per cent. of sunshine in Table I corresponds to a falling range of somewhere about 15 per cent. of sunshine plus cloud.

We may judge from these results that a sunshine recorder is not (as it is sometimes asserted to be) an automatic device for determining the average cloudiness of the sky. Both sunshine and cloudiness have common elements it is true, yet they are no more convertible terms than are, say, the temperatures of the air and of radiation, or, better still, than are evaporation and rainfall.

Greatest and least monthly percentages of sunshine recorded and cloudiness observed, 1900 to 1919, are given in Table IV. Here the cloudiness is deduced from six observations a day, two being night hours.

TABLE IV.—*Monthly Maxima and Minima of Sunshine and Cloud.*

	Sunshine.			Cloud.		
	Max.	Min.	Range.	Max.	Min.	Range.
	(%).	(%).	(%).	(%).	(%).	(%).
January . . .	83	63	20	59	26	33
February . . .	83	59	24	65	31	34
March . . .	84	62	22	52	26	26
April . . .	91	69	22	43	13	30
May . . .	94	68	26	43	5	38
June . . .	90	74	16	31	9	22
July . . .	92	68	24	35	3	32
August . . .	95	72	23	33	5	28
September . . .	89	65	24	45	11	34
October . . .	90	67	23	48	22	26
November . . .	92	66	26	55	16	39
December . . .	84	71	13	48	25	23

Thus there has been an August (1906) with almost uninterrupted sunshine, and a July (1914) with only 3 per cent. of cloud. June has never had more and February never less than 31 per cent. of sky clouded—the June maximum in 1913, the February minimum in 1919.